PRODUCT SIMPLIFICATION DESIGN IMPROVEMENT BY USING DFMA METHOD

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Report submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering

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JUNE 2012

ABSTRACT

Design for Manufacturing and Assembly (DFMA) is a tool for designing or redesign product. The advantage of DFMA is able to reduce manufacturing cost. The main objective of this project is to propose a new design for price labeler. Apart from that, the manufacturing cost, assembly cost and time are also analysed to support the improvement. The analysed were carried out through dismantle a unit of product, functioning of each component and 3D modelling using SolidWork software and lastly is using DFMA design guidelines to generate a new design. The selection criteria for a good design are based on manufacturing cost and assembly time. Finally, the chosen design was proven meet all needed criteria by improving 16.29% of the design efficiency. The existing product design efficiency is 26.62% and the new propose of design is 41.26%. The labour cost also manages to reduce RM0.1940 per product. For the Design for Manufacturing (DFM) part, the better manufacturing process chooses is injection moulding and the material used is Thermoplastic. Since the material choose is Thermoplastic, so will maintain the original material which is *Acrylonitrile butadiene styrene* (ABS). In this study, the overall cost reduction for DFMA is RM0.19 per product which is RM1.50 reduce to RM1.31, the percentage reduction is 12.67%.

ABSTRAK

Deign for Manufacturing and Assembly (DFMA) adalah kaedah untuk mereka bentuk produk atau rekan bentuk semula satu produk. Kelebihan DFMA dapat mengurangkan kos pengeluaran. Objektif utama project ini adalan untuk mencadangkan reka bentuk baru untuk Pelabel harga. Selain daripada itu, kos pengeluaran, kos pemasangan dan masa juga dianalisis untuk menyokong peningkatan. Project ini dijalankan dengan mengurangkan komponen dalam produk, mengenalpastikan fungsi-fungsi setiap komponen, pemedelan 3D mengunakan perisian SolidWork and seterusnya mengunakan garis panduan rekan bentuk DFMA untuk menghasilkan reka bentuk baru. Kriteria pemilihan bagi reka bentuk yang baik adalah berdasarkan kepada kos pembuatan dan masa pemasangan. Akhir sekali, reka bentuk yang dipilih telah meningkat kecekapan rekanbentuk sebanyak 16.29%. Kecekapan reka bentuk produk yang sedia ada adalah 26.62% dan reka bentuk baru adalah 41.26%. Kos buruh juga berjaya mengurangkan sebanyak RM0.1940 bagi setiap produk. Bagi Design for Manufacturing (DFM), proses pembuatan yang terbaik adalah acuan suntikan dan bahan yang digunakan adalah termoplastik. Produk yang sedia mengunakan Akrilonitril butadiena stirena (ABS) sebagai bahan, jadi reka bentuk baru juga akan mengunakan bahan ABS. Dalam kajian ini, pengurangan kos keseluruhan untuk DFMA adalah RM0.19 bagi setiap produk, kos bahan dapat mengurangkan dari RM1.50 kepada RM1.31, pengurangan peratusan adalah 12.67%.

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LIST OF SYMBOLS

E_{ma}	Design efficiency
N_{min}	Theoretical minimum number of parts
T_a	Basic assembly time = 3 second
E_d	Functional efficiency
T_{ma}	Estimated time to complete the assembly of the product
E_d	Functional efficiency

LIST OF ABBREVIATIONS

DFA	Design for Assembly
DFM	Design for Manufacture
DFMA	Design for Manufacture and Assembly
CE	Concurrent Engineering
PTFE	Polytetrafluoro ethylene
AEM	Assemblability Evaluation Method
CAE	Computer-aided engineering

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Design for Manufacturing and Assembly (DFMA) method is introduced by Geoffrey Boothroyd since 1960s on automatic handling. The method of Design for Manufacturing and Assembly (DFMA) can be used to redesign a product. DFMA is the combination between Design for Manufacturing (DFM) and Design for Assembly (DFA). DFM is manufacturing of individual component parts of a product or assembly while DFA is addition or joining of parts to form a complete product. DFMA can help us to simplify the product structures, reduce the assembly and manufacturing costs and assembly time. By using this method, the quality of existing product can be improved and cost can be reduced.

The main activities of the DFMA are concurrent engineering to provide guidance to design team in simplifying the product structure, to reduce manufacturing and assembly costs and to qualify improvements. Besides, it is also used as a benchmarking tool to study competitors' products, and as a should-cost tool to negotiate contract with the supplier.

Basically, the objective of this study is to redesign a new selection of products for a better design and lower production cost. Hence, the DFMA method has been applied to analyse the original product (Price Labeler). DFMA is used to make a new design which can reduce the assembly costs, material cost, time and increase design efficiency. Lastly, in this chapter, the overall thesis outline is reviewed and discussed in general.

1.2 PROJECT BACKGROUND

Original DFA method development stemmed from earlier work in 1960s on automatic handling. In 1988, Ford Motor Company has applied this method to help the company to save a billion dollars of capital and improve the design efficiency. Because of the effectiveness of the DFA method, General Motor also becomes one of the leading users of DFMA. Besides automatic handing sector, DFMA is also applied in industry sector, medical, aerospace, manufacturing equipment, etc. Although its benefits used in some company, but some of the company still could not implement the DFMA method.

The focus of DFMA is to help the design team to simplify the product structure, improve the design quality, reliability, minimize the assembly and manufacturing costs, and other cost sources are considered, as well as to encourage the spirit of team work among designers. Teamwork is very important to a group of team members; they can discuss the problem facing and solve it together (Luo, 2007). On the other hand, DFMA is also important to study competitors' products and processes from a design, quality, material selection, number of components, manufacturing method, point of view and then evaluate assembly or manufacturing difficulties in an effort to design a superior product based upon the results of this detailed analysis.

Nowadays, there are many types of price labeler available in the market, but the cost of design is too high for users, it needs a lot of improvement in terms of design and assembly time. So, DFMA can help to improve the design efficiency, cost and customers' need. In this study, the requirement is the parts function have to be same as the original when redesigning the parts; Thus, this study is able to expose to the field in calculating the current design efficiency of the price labeler and the modification of the current design by eliminating and simplifying some of the part to achieve a better design and convenient to the users.

1.3 PROBLEM STATEMENTS/ PURPOSE OF STUDIES

Price labeler recently has become a very common product in our daily life especially for shopkeepers. Price labeler is a common product, but the price is not affordable for small shopkeepers. Manually labeling price tag by using hand will waste time. Hence, product life volume must be high in this product to fulfil the requirement of the user.

The purpose of this study is to redesign a price labeler to improve in term of product design and optimization in assembly and manufacturing process for a production. Basically, there are a lot of designs ready in the market but there are no fix designs and they consist of many components and parts. When need to service, it is very difficult to assemble which means it takes more time to be assembled. Therefore, a simplified design of the price labeler will bring more advantages towards the company.

As a conclusion, Boothroyd-Dewhurst method is applied to redesign and reconstruct to produce a higher quality and lower cost of production. This method can reduce manufacturing and assembly cost, improve the quality of the production and simplifying the product structure. Furthermore, continue development will produce higher technology in manufacturing industry in our country.

1.4 OBJECTIVES OF STUDIES

The objectives of this study are:-

(i) To propose and improve design for price labeler.
(ii) To analyse and improve the product design efficiency.
(iii) To reduce the manufacturing cost for price labeler.

1.5 SCOPES

The scopes of this project are:-

(i) Price labeler MOTEX (MX5500) as the product for this project.
(ii) Boothroyd-Dewhurst DFMA is selected as the DFA tool.
(iii) SolidWork software as modelling drawing of the current product.
(iv) Literature review on product improvement using DFMA approaches.
(iv) Apply DFMA methodology to identify design problems and generate remedial design solutions.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter discusses about the following sub-chapters; design for manufacturing and assembly, theory of inventive problem solving, review on previous case studies and perspective approach.

2.2 DESIGN FOR MANUFACTURING AND ASSEMBLY (DFMA)

DFMA is a method to improve the adaptability and efficiency during times of change. This idea can effort the use of the experience of previously done mistakes to speed up the development process and also accomplish new technologies and philosophies to ensure that activities which more faster and give more precise results that can really reach this target (Pedro, 2006). DFMA is a combination between Design for Manufacturing (DFM) and Design for Assembly (DFA). DFM is manufacturing of individual component parts of a product or assembly while the DFA is the addition or joining of parts to form a complete product (Boothroyd, 2002). Figure 2.1 show the comparison between the DFMA and the traditional method which used before the DFMA has been developed.

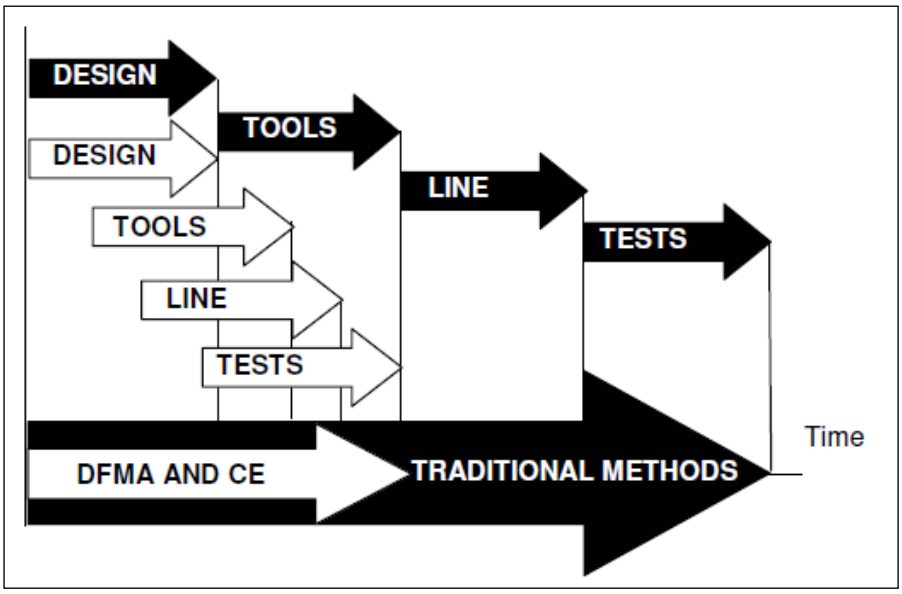


Figure 2.1: Time to Deliver Comparison between DFMA + Concurrent Engineering (CE) and the Traditional Methods

Source: Pedro (2006)

According to Boothroyd (2002), it is about twenty years he have been working in the area of product design manufacturing and assembly (DFMA), it have been developed and discovered applied in industry—particularly U.S. industry. In fact, it can be said that the availability of these methods have created a revolution in the product design business and helped to break down the barriers between design and manufacture; it has also allowed the development of concurrent or simultaneous engineering.

Guidice (2009) said that DFMA is a method to analysis and improvement of the existing product, again implemented in commercially available computer software. DFMA developed is possible to optimize manufacturing's cost, invent a most efficient and economical product. It also allows the analysis of each individual's component and its assembly in order to define the optimal solutions, facilitating the assembly of subsystems and of the final product. From Boothroyd (2002) said, in the earliest stage, DFMA is able to estimate both assembly and part of manufacturing cost.

DFMA would be a workstation-like environment at which a designer could create a design in terms beyond just geometry, and accessing to capabilities for design trade-off studies, cost reduction studies, producibility evaluations, design rule checking, and manufacturing and assembly evaluations and recommendations. It will act like a manufacturing expert looking over the designer's shoulder, providing a god suggestions, comments about the design and the defect of the design pattern, and information about fabrication and assembly (De Fazio T. L., 1993).

Tianhong Luo (2007) said DFMA is a methodology, this method can improve the integration between designer and manufacturer, speed up the productivity cycle, reduce the cost, improve product quality and reliability, to shorten lead time, to increase productivity and fulfil the customer’s requirements. Hence, DFMA is a method to reduce the design and assembly cost to simplify the structure of the product, improve the quality and reliability to compare with the existing product. This method must be done at the earliest state to avoid from the overhead cost under the consideration of design team, the spirit of the co-operation is very important in this process.

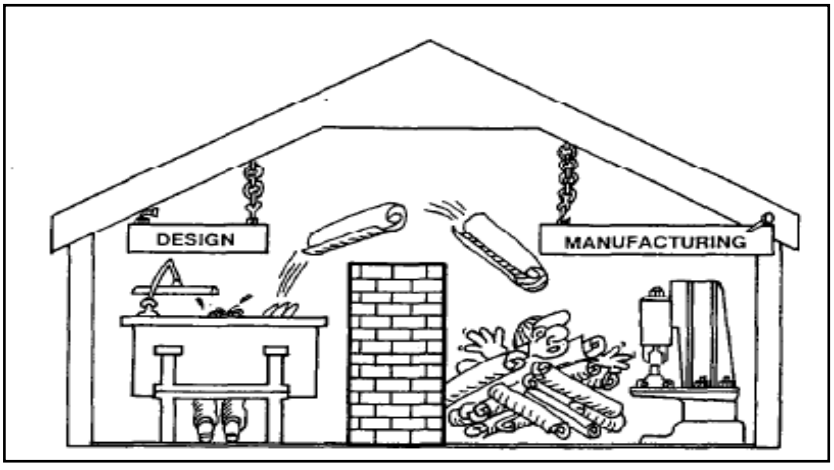


Figure 2.2: “Over the Wall Design”

Source: Boothroyd.G (1992)

"We design it, you build it." This attitude has now become known as "over-the-wall" design which means the designer did not care about the manufacturing engineer, they think that their responsibility is to draw and design the drawing then after that throw all the drawing to aside for manufacturing engineer. They are facing a lot of manufacturing problem because they were not involved in design effort (Boothroyd.G, 1992).

2.3 DESIGN FOR ASSEMBLY (DFA)

Design for Assembly (DFA) has been taking seriously in early 1960s. The development of this method is to work and overcome benefit to the company who using this method (Boothroyd, 2002).

DFA method should be carefully considered at all stages of design in the early stages so that can estimate the cost and time properly. The team design should provide quick results and to simplify so that they are easy to use. It also should ensure consistency and completeness in its evolution of product assembility. Beside this, communication is very important for manufacturer and designer engineer, so it should be improved. The idea, reasoning and decision made during the design process become well documented for future references (Boothroyd, 2002; Pedro, 2006). DFA is the design of the product for ease of assembly; it is using a systematic procedure step by step to estimating assembly time and cost in the early stage. Teamwork is very important for the designer and manufacturer to consider together to the structure of the product, the purpose is to make adjustment to the design or parts and they will get a immediate feedback of the effect of such change (Geng, 2004).

The objective of DFA method for these parts in a design is guiding the designer to simplify the structure through combinations of parts or features, alternative choices of securing methods or spatial relationship changes. Providing a tool for the designer team to assists in the determination of the most efficient fastening methods for necessary interfaces between separate items in a design. This is an important consideration since separate fasteners are often the most labour intensive group of items when considering mechanical assembly work. Consideration of the fastening method is very important

because 47% of assembly time is spent on the insertion and tightening of separate screw and nuts (Geng, 2004).

Method	Assembly time (s)
Snap Fit	4.1
Press Fit	7.3
Integral Screw Fastener	11.5
Rivet (4)	36.1
Machine Screw (4)	40.5
Screw/ Washer/ Nut (4)	73.8

Table 2.1: Alternative Fastening Arrangement

Source: Geng (2004)

In addition, the another objective is when starting to design something, the senior designer will collect all the information about the design structure and arrange it properly for junior designer engineer and estimate the assembly time, cost and the factor which will cause the defect. Then they continue the procedure step by step. So that overhead cost will not happen (Boothroyd, 2002).

Boothroyd Dewhurst DFA method is providing three criteria to give guidance to the designer in reducing the part count, if the part does not satisfy at least one of these three criteria, then it is considered to be a candidate for eliminate. The three criteria (Boothroyd, 2002) are: -

(i) The part move relative to all other parts already assembled

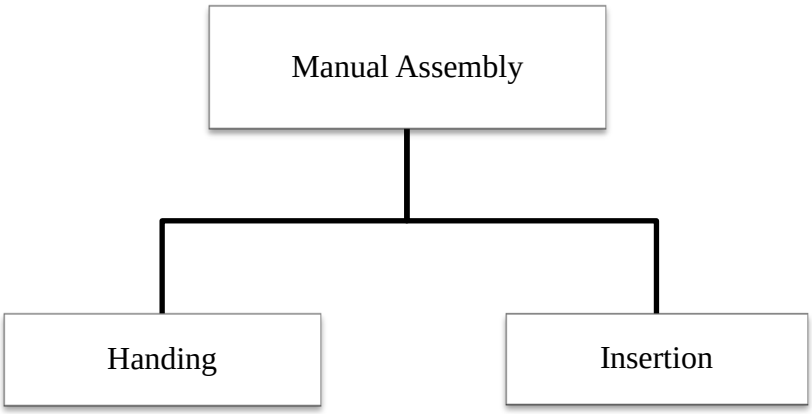
(ii) The part be a different material than or be isolated from all other parts already assemble.

(iii) The part be separated from all other parts already assembled because otherwise necessary assembly or disassembly.

*Therefore none of the three criteria are met and the strap becomes a candidate for elimination. For the strap a zero is placed in the column for minimum parts.

2.3.1 Manual Assembly

The process of manual assembly can be divided into two separate areas. Those are handing and insertion (Boothroyd, 2002; Geng, 2004).



2.3.1.1 Handing

Handing is including the acquiring, orienting and moving the parts. In general, for case of part handing, a designer should attempt to:

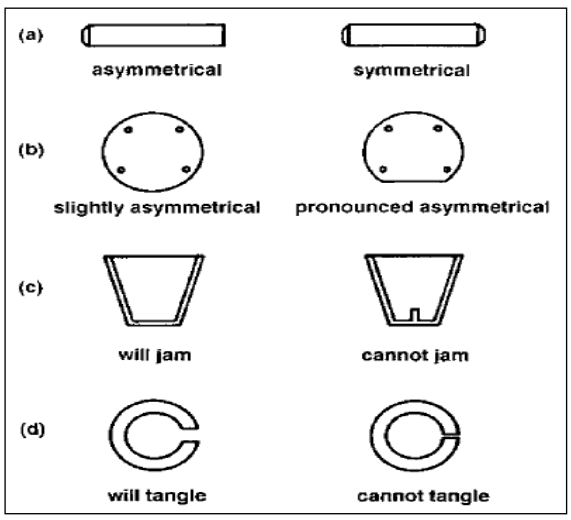


Figure 2.3: Geometrical Features Affecting Part Handing

Source: Boothroyd (2002)

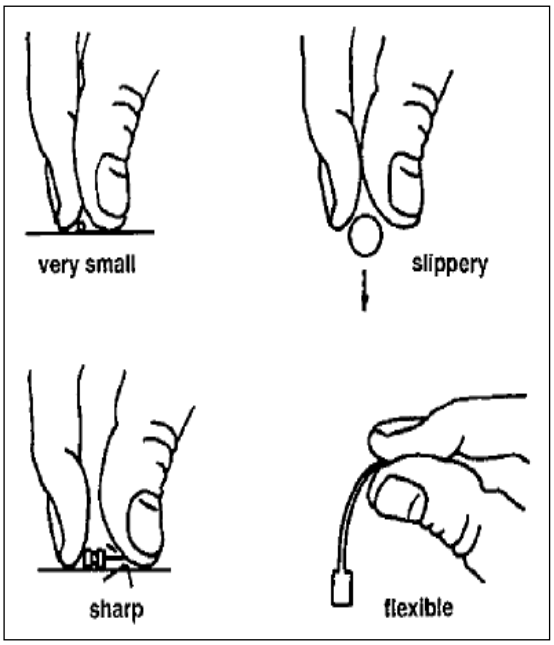


Figure 2.4: Some Other Features Affecting Part Handling

Source: Boothroyd (2002)

i. Design parts that have end-to-end symmetry and rotational symmetry about the axis of insertion. If this cannot be achieved, try to design parts having the maximum possible symmetry (see Fig. 2.4a).

ii. Design parts that, in those instances where the part cannot be made symmetric, are obviously asymmetric (see Fig. 2.4b).

iii. Provide features that will prevent jamming of parts that tend to nest or stack when stored in bulk (see Fig. 2.4c).

iv. Avoid features that will allow tangling of parts when stored in bulk (see Fig. 2.4d).

v. Avoid parts that stick together or are slippery, delicate, flexible, very small, or very large or that are hazardous to the handler (i.e., parts that are sharp, splinter easily, etc.) (see Fig. 2.5)

2.3.1.2 Insertion

Insertion is mating a part to another part or group of parts. For ease of insertion a designer should attempt to (Boothroyd, 2002).

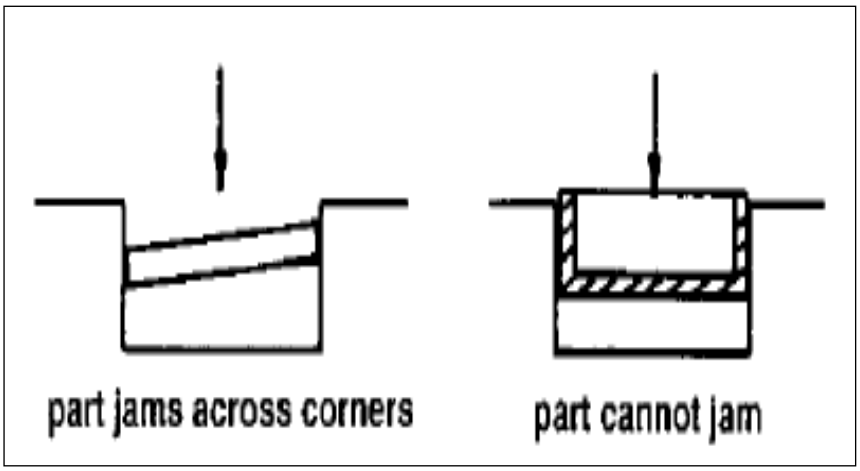


Figure 2.5: Incorrect Geometry can Allow Part To Jam During Insertion

Source: Boothroyd (2002)

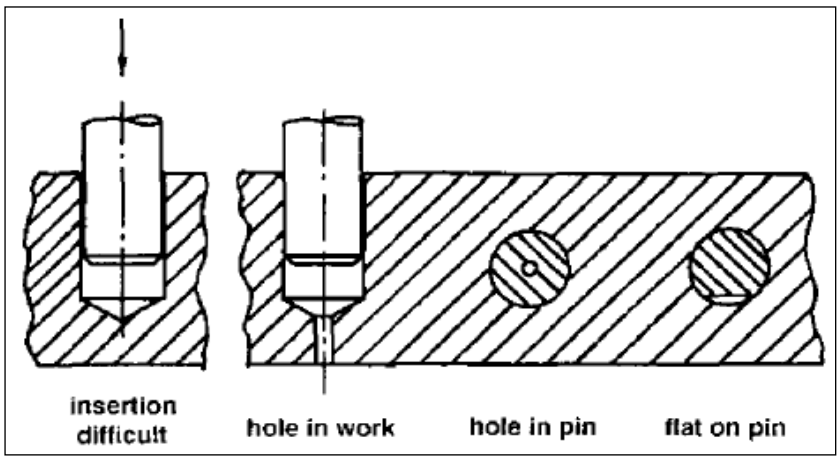


Figure 2.6: Provision of Air-Relief Passages to Improve Insertion into Blind Holes

Source: Boothroyd (2002)